(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 November 2002 (21.11.2002)

PCT

(10) International Publication Number
WO 02/092956 A1

(51) International Patent Classification⁷: E21B 7/18, B24C 5/00

(21) International Application Number: PCT/EP02/02509

(22) International Filing Date: 6 March 2002 (06.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
01302047.4 6 March 2001 (06.03.2001) EP

(71) Applicant *(for all designated States except CA, US)*: **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL).

(71) Applicant *(for CA only)*: **SHELL CANADA LIMITED** [CA/CA]; 400, 4th Avenue S.W., Calgary, Alberta T2P 2H5 (CA).

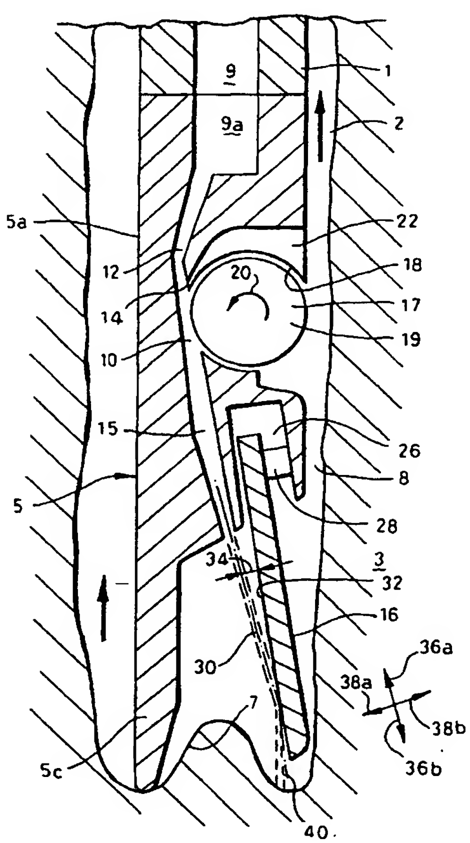
(72) **Inventor; and**
(75) **Inventor/Applicant** *(for US only)*: **BLANGE, Jan, Jette** [NL/NL]; Volmerlaan 8, Nl-2288 Gd Rijswijk (NL).

(81) **Designated States** *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

[Continued on next page]

(54) Title: JET CUTTING DEVICE WITH DEFLECTOR



(57) Abstract: A jet cutting device comprising a cutter head provided with at least one nozzle for ejecting a stream of fluid against a body so as to create a selected cut in said body, is discloded. For each nozzle, the cutter head is provided with a deflector having a deflection surface arranged to deflect the stream of fluid ejected by the nozzle into a selected direction in accordance with the position of said cut to be created.

WO 02/092956 A1

Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

JET CUTTING DEVICE WITH DEFLECTOR

The invention relates to a jet cutting device comprising a cutter head provided with one or more nozzles for ejecting a stream of fluid against a body so as to create a cut in the body. The jet cutting device can be applied, for example, in the industry of machining work pieces or in the industry of rock cutting during drilling of boreholes into the earth formations.

WO 00/66872 discloses a rock cutting device whereby a stream of drilling fluid containing abrasive particles is ejected against the borehole bottom or borehole wall by a nozzle provided at a cutter head of the device.

A problem of the known device is that the direction of the ejected stream cannot be as optimal as desired in view of limitations regarding the position of the nozzle at the cutter head. For example in certain applications it is desirable that the ejected stream passes close to, and substantially parallel to, the borehole wall in order to accurately cut the borehole circumference. However, the position of the nozzle inwardly from the outer radius of the cutter head prevents such stream direction.

It is therefore an object of the invention to provide an improved jet cutting device which overcomes the aforementioned problem.

In accordance with the invention there is provided a jet cutting device, comprising a cutter head provided with at least one nozzle for ejecting a stream of fluid against a body so as to create a selected cut in said body, wherein, for each nozzle, the cutter head is provided with a deflector having a deflection surface arranged to deflect the stream of fluid ejected by the

nozzle into a selected direction in accordance with the position of said cut to be created.

It is thereby achieved that the ejected stream can be deflected in directions other than the direction of ejection of the stream from the nozzle.

The jet cutting device is attractive for wellbore drilling, as it allows to drill a central part of the borehole by a portion of the stream not deflected by the deflector, and to drill a radial outer part of the borehole by a portion of the stream deflected by the deflector positioned close to the borehole wall thus allowing the outer circumference of the borehole to be accurately cut.

To focus the stream and to increase the cutting efficiency, the deflector suitably has a concave deflection surface onto which the stream impacts. Alternatively, when it is desired to diverge the stream, the nozzle can be arranged to eject the stream against a convex deflection surface of the deflector.

Since for most applications the intensity of the impact force from the stream on the deflection surface varies somewhat along the surface, suitably the deflection surface has an erosion resistance which varies along the deflection surface in accordance with the variation of the impact force so that the deflection surface is substantially uniformly eroded by the stream.

The invention will be described hereinafter in more detail and by way of example with reference to the accompanying drawings in which

Fig. 1 schematically shows a longitudinal section of an embodiment for borehole drilling of the jet cutting device of the invention; and

Fig. 2 schematically shows a detail of the embodiment of Fig. 1.

Referring to Fig. 1 there is shown a drilling assembly including a drill string 1 extending into a borehole 2 formed in an earth formation 3 and a jet cutting device 5 arranged at the lower end of the drill string 1 near the bottom 7 of the borehole 2, whereby an annular space 8 is formed between the drilling assembly 1 and the wall of the borehole 2. The drill string 1 and the jet cutting device 5 are provided with a fluid passage 9, 9a for drilling fluid to be jetted against the borehole bottom, as is described hereinafter. The jet cutting device 5 has a cutter head 5a provided with a mixing chamber 10 having a first inlet in the form of inlet nozzle 12 in fluid communication with the fluid passage 9, 9a, a second inlet 14 for abrasive particles and an outlet in the form of jetting nozzle 15 directed towards a deflector 16 which is described hereinafter in more detail. A longitudinal extension 5c of cutter head 5a is provided to keep the jetting deflector 16 a selected distance from the borehole bottom 7. A recess 17 is arranged in the cutter head 5a at the side surface thereof, which is in fluid communication with the mixing chamber 10 and with the second inlet 14.

Fig. 2 shows a perspective view of the recess 17 whereby a semi-cylindrical side wall 18 of the recess 17 has been indicated. A cylinder 19 rotatable in direction 20 (cf. Fig. 1; in Fig. 2 the cylinder has been removed for clarity purposes) is arranged in the recess 17, the diameter of the cylinder being such that only a small clearance is present between the cylinder 19 and the side wall 18 of the recess 17. The outer surface of the cylinder 19 has been magnetised, whereby a number of N and S poles alternate in circumferential direction. The second inlet 14 and the mixing chamber 10 each have a side wall formed by the outer surface of the cylinder 19. Furthermore, the second inlet 14 has opposite side

walls 22, 24 which converge towards the mixing chamber 10 and which extend substantially perpendicular to the side wall 18.

The deflector 16 extends into a lower recess 26 of the cutter head 5a in a manner allowing movement of the deflector 16 relative to the cutter head 5a. A control means in the form of actuator 28 is arranged in the lower recess 26 to support the deflector 16 and to control movement of the deflector 16 relative to the cutter head 5a. The deflector 16 is arranged so that during operation of the jet cutting device 5 a stream of fluid 30 ejected by the nozzle 15 impacts onto inner surface 32 of the deflector at a selected angle 34. The inner surface 32 is preferably made of an erosion resistant material like Tungsten Carbide.

The actuator 28 is capable of moving the deflector in opposite directions 36a, 36b which are substantially parallel to the deflector inner surface 32 and opposite directions 38a, 38b, which are substantially perpendicular to the deflector inner surface 32. Furthermore the actuator 28 is capable of rotating the actuator so as to change the angle 34 at which the stream 30 impacts on the deflector inner surface 32.

During normal operation of the drilling assembly 1, a stream of drilling fluid initially containing abrasive particles is pumped via the fluid passage 9, 9a and the inlet nozzle 12 into the mixing chamber 10. The abrasive particles include a magnetically active material such as martensitic steel, and typical abrasive particles are martensitic steel shot or grit. The stream flows through the jetting nozzle 15 in the form of a jet stream 30 against the deflector 16 which deflects the stream 30 to form deflected stream 40 impacting against the borehole bottom 7. The direction of deflected stream 40 is

determined by the angle of impact 34, the deflector shape and the deflector orientation.

After all abrasive particles have been pumped through the fluid passage 9, 9a, drilling fluid which is substantially free of abrasive particles is pumped through the passage 9, 9a and the inlet nozzle 12 into the mixing chamber 10.

By the impact of the jet stream 40 against the borehole bottom 7, rock particles are removed from the borehole bottom 7. The drill string 1 is simultaneously rotated so that the borehole bottom 7 is evenly eroded resulting in a gradual deepening of the borehole. The rock particles removed from the borehole bottom 7 are entrained in the stream which flows in upward direction through the annular space 8. As the stream passes the cylinder 19 the abrasive particles are attracted by the magnetic forces induced by cylinder 19, which magnetic forces thereby separate the abrasive particles from the stream and move the particles onto the outer surface of the cylinder 19. The cylinder 16 is induced to rotate a) due to frictional forces exerted to the cylinder by the stream of drilling fluid flowing into the mixing chamber, b) due to frictional forces exerted to the cylinder by the stream flowing through the annular space 8, and c) due to the high velocity flow of drilling fluid through the mixing chamber 10 which generates a hydraulic pressure in the mixing chamber 10 significantly lower than the hydraulic pressure in the annular space 8. The abrasive particles adhered to the outer surface of the cylinder 16 thereby move through the second inlet 14 in the direction of the mixing chamber 10. The converging side walls 22, 24 of the second inlet 14 guide the abrasive particles into the mixing chamber 10. Upon arrival of the particles in the mixing chamber 10 the stream of drilling fluid ejected from the inlet nozzle 12

removes the abrasive particles from the outer surface of the cylinder 19 whereafter the particles are entrained into the stream of drilling fluid.

The remainder of the stream flowing upwardly through the annular space 8 is substantially free of abrasive particles and continues flowing upwardly to surface where the drill cuttings can be removed from the stream. After removal of the drill cuttings the drilling fluid is pumped through the fluid passage 9, 9a and the inlet nozzle 12, into the mixing chamber 10 so as to entrain again the abrasive particles, etc.

When the area of deflector surface 32 where the stream 30 impacts becomes worn, the actuator 28 is induced to move the deflector 16 either in direction 36a or 36b so as to displace said area away from the location of impact and to position a new area of deflector surface 32, not worn, at the location of impact. In this manner it is achieved that the life time of the deflector is increased.

When it is desired to change the direction of the deflected stream 40, the actuator 28 is induced to rotate the deflector so as to change the angle 34 at which the stream 34 impacts on the deflector.

Furthermore when it is desired to increase the diameter of the borehole 2 drilled, the actuator 28 is induced to move the deflector 16 in the direction 38b thereby increasing the distance between the deflector 16 and the stream 30. Conversely, when it is desired to decrease the diameter of the borehole 2 drilled, the actuator 28 is induced to move the deflector 16 in the direction 38a thereby decreasing the distance between the deflector 16 and the stream 30.

CLAIMS

1. A jet cutting device, comprising a cutter head provided with at least one nozzle for ejecting a stream of fluid against a body so as to create a selected cut in said body, wherein, for each nozzle, the cutter head is provided with a deflector having a deflection surface arranged to deflect the stream of fluid ejected by the nozzle into a selected direction in accordance with the position of said cut to be created.

2. The jet cutting device of claim 1, wherein said pump means is arranged to induce a stream of liquid including abrasive particles through the nozzle.

3. The jet cutting device of claim 1 or 2, wherein the deflection surface is concave.

4. The jet cutting device of any one of claims 1-3, wherein the impact force of the stream on the deflection surface varies along the deflection surface, and wherein the deflection surface has an erosion resistance which varies along the deflection surface in accordance with the variation of the impact force of the stream on the deflection surface so that the deflection surface is substantially uniformly eroded by the stream.

5. The jet cutting device of any one of claims 1-4, wherein the deflector is movable relative to the cutter head, and the jet cutting device further includes control means for controlling movement of the deflector relative to the cutting head.

6. The jet cutting device of claim 5, wherein the control means is arranged to move the deflector so as to displace a first portion of the deflection surface away from the location at which the stream impacts on the

deflection surface, and to position a second portion of the deflection surface at said location.

7. The jet cutting device of claim 5, wherein the control means is arranged to move the deflector so as to change the angle at which said stream impacts on the deflector.

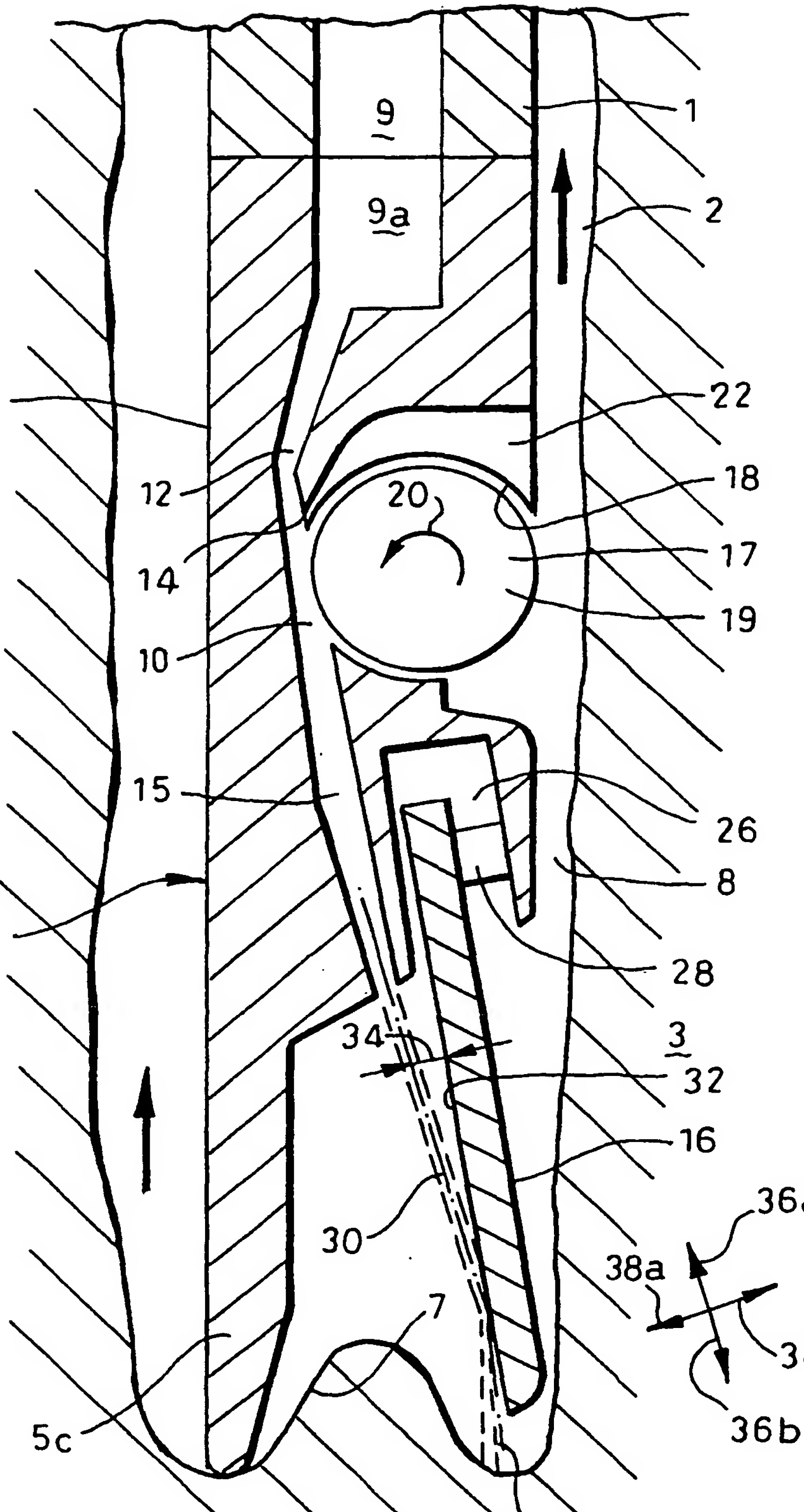
8. The jet cutting device of claim 5, wherein the control means is arranged to move the deflector in a translating movement so as to change the distance between the deflector and said stream.

9. The jet cutting device of any one of claims 1-8, wherein the cutter head forms part of a drill string for drilling a borehole into an earth formation, and wherein each nozzle is arranged to eject a stream of fluid including abrasive particles into the borehole so as to further drill the borehole.

10. The jet cutting device of claim 9, wherein each nozzle is arranged to drill a central part of the borehole by a portion of the stream ejected by the nozzle not deflected by the deflector, and to drill a radial outer part of the borehole by a portion of the stream deflected by the deflector positioned close to the borehole.

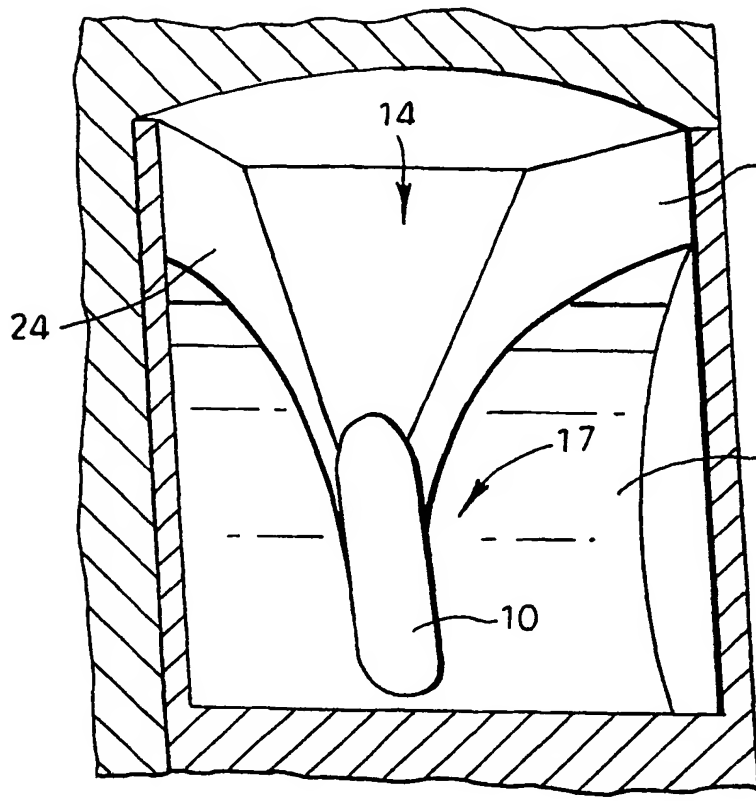
11. The jet cutting device substantially as described hereinbefore with reference to the drawings.

Fig.1.



9
9a
1
2
22
5a
12
18
20
17
14
19
10
15
26
8
5
28
34
3
32
16
36a
30
38a
7
38b
5c
36b
40

Fig.2.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/02509

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B7/18 B24C5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B B24C B26F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 708 214 A (KRAWZA WALTER G ET AL) 24 November 1987 (1987-11-24) column 4, line 50 -column 5, line 7; figure 3	1,2,5,9, 10
X	US 5 664 992 A (WILLIAMS JR ROBERT V) 9 September 1997 (1997-09-09) column 3, line 48 - line 52 column 5, line 9 - line 15; figures 5,7-9	1-3
A	WO 00 66872 A (SHELL CANADA LTD ;SHELL INT RESEARCH (NL)) 9 November 2000 (2000-11-09) cited in the application figure 1	1-11

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 August 2002	16/08/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Garrido Garcia, M

1

Form PCT/ISA/210 (second sheet) (July 1992)

International Application No
PCT/EP 02/02509

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 897 836 A (HALL J MICHAEL ET AL) 5 August 1975 (1975-08-05) column 2, line 62 - line 64 ---	1-11
A	US 6 062 311 A (SCOTT DAVID ET AL) 16 May 2000 (2000-05-16) column 4, line 4 - line 22 -----	1-11

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/02509

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4708214	A	24-11-1987	US	4663893	A	12-05-1987
			CA	1264732	A1	23-01-1990
US 5664992	A	09-09-1997	US	5885133	A	23-03-1999
WO 0066872	A	09-11-2000	AU	4564300	A	17-11-2000
			BR	0010111	A	19-02-2002
			CN	1349585	T	15-05-2002
			WO	0066872	A1	09-11-2000
			EP	1175546	A1	30-01-2002
			NO	20015170	A	23-10-2001
US 3897836	A	05-08-1975	NONE			
US 6062311	A	16-05-2000	GB	2324818	A	04-11-1998
			CA	2236563	A1	02-11-1998